(12) UK Patent Application (19) GB (11) 2 227 370 (13) A

(43) Date of A publication 25.07.1990

(21) Application No 8924912.2

(22) Date of filing 03.11.1989

(30) Priority data
(31) 63277328 (32) 04.11.1988 (33) JP

(51) INT CL^5
H01Q 1/38

(52) UK CL (Edition K)
H1Q QFA QKA
U1S S2204

(56) Documents cited
None

(58) Field of search
UK CL (Edition J) H1Q QDN QFA QFC QFH QFJ QFS QFU QFX QKA QKX
INT CL^4 H01Q

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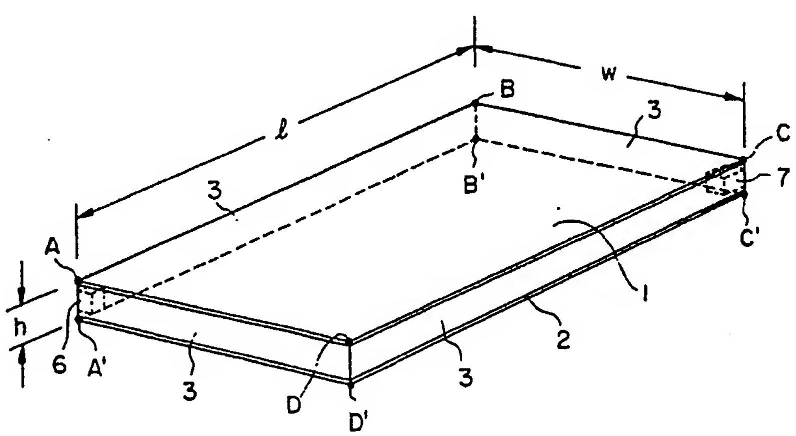
(54) Antenna

(57) An antenna, in which a pair of rectangular conductor plates (1, 2) disposed in parallel with a spacing sufficiently smaller than the wavelength used, are fixed with respect to each other by an insulating frame (3) to form an antenna structure which also acts as a case. A pair of feed terminals (D, D') is provided at a desired position one on each of the conductor plates. High-frequency-wise short-circuit elements (6, 7) are provided at a plurality of positions on the conductor plates remote from the feed terminals. A gravity-direction sensor which produces an output in accordance with the direction of gravity, is provided in the case. The plurality of short-circuit elements are selectively short-circuited by the output of the gravity-direction sensor so that the plane of polarization of the antenna is brought into agreement with the direction of gravity.

Fig. 2A



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1/5

Fig. 1A

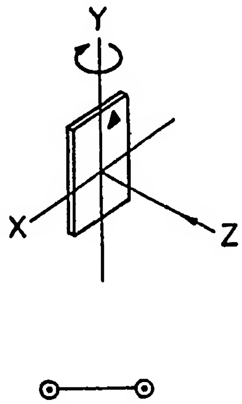


Fig. 1B

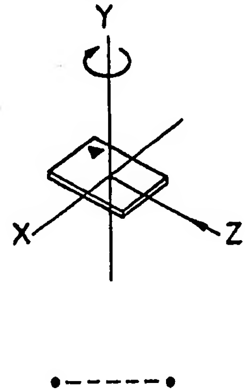


Fig. 1C

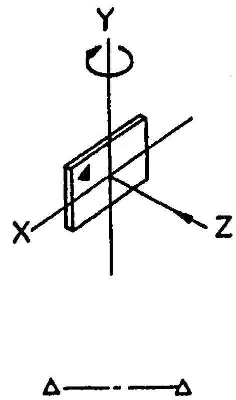
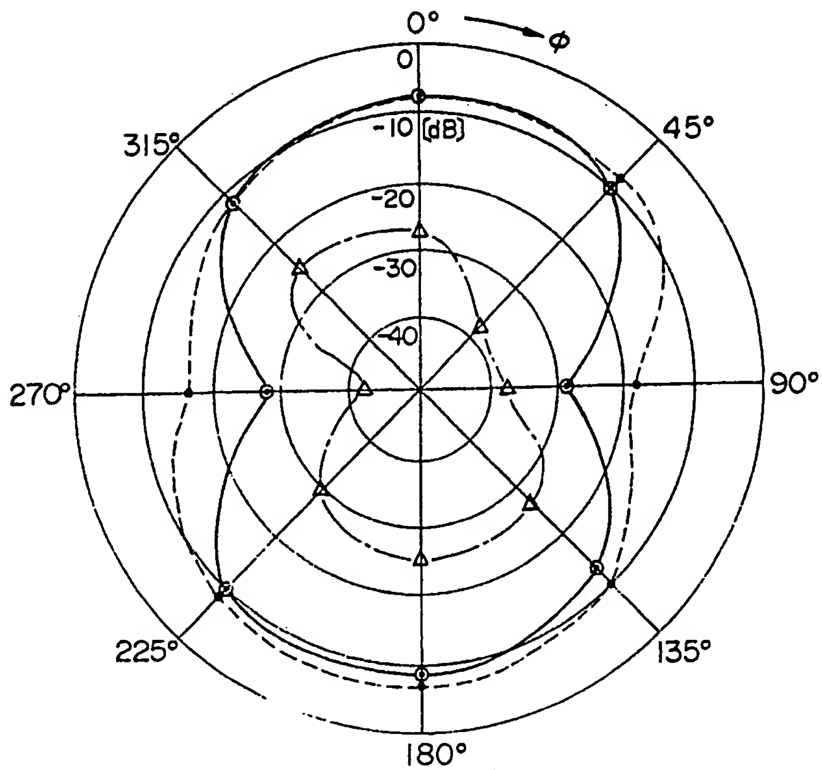


Fig. 1D



2/5

Fig. 2A

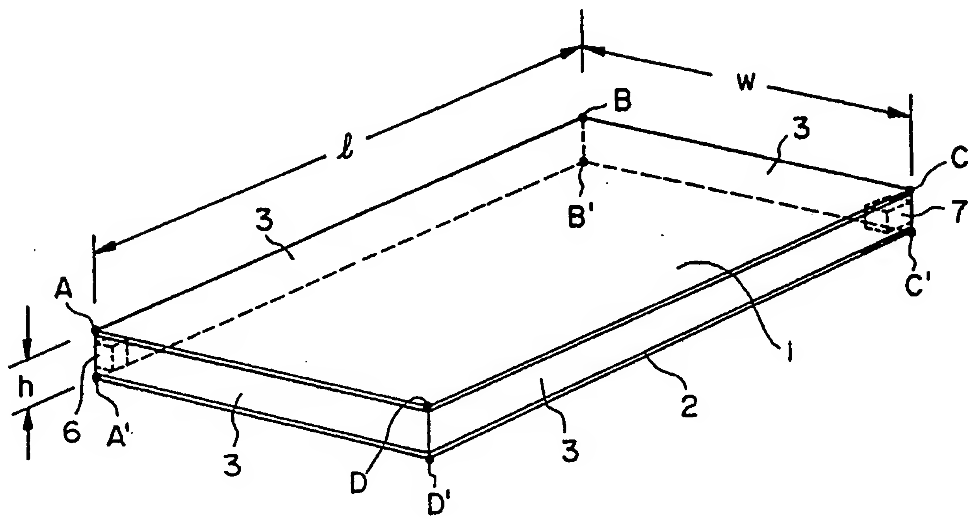
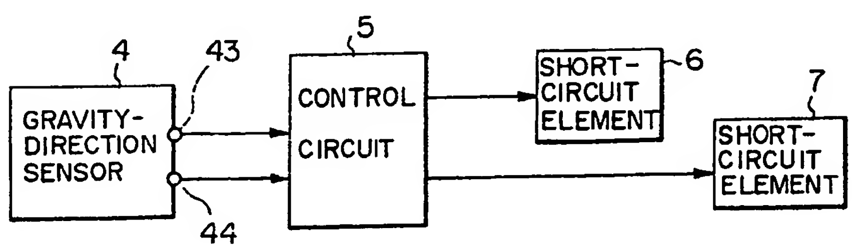


Fig.2B



3/5

Fig. 3A

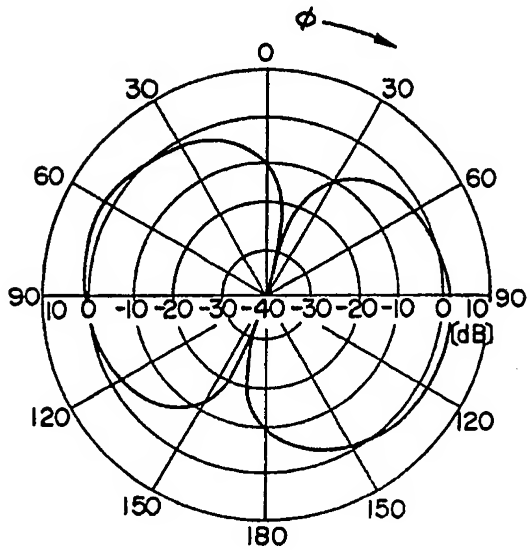


Fig. 3B

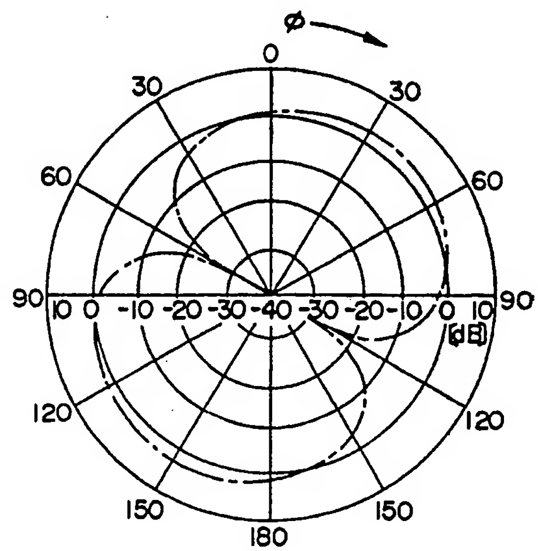


Fig. 3C

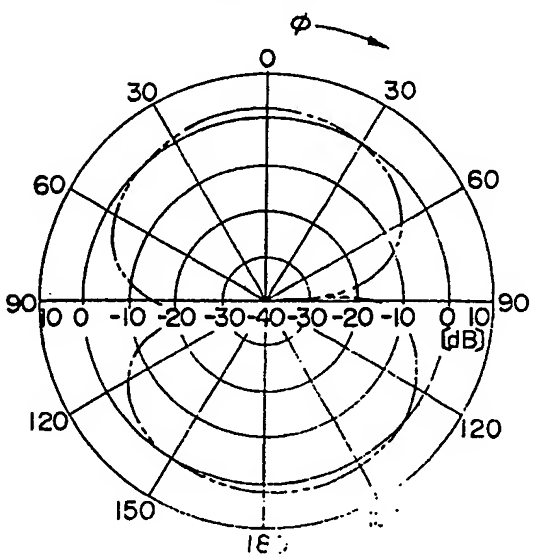


Fig. 3D

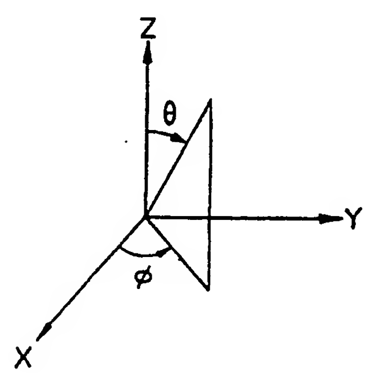
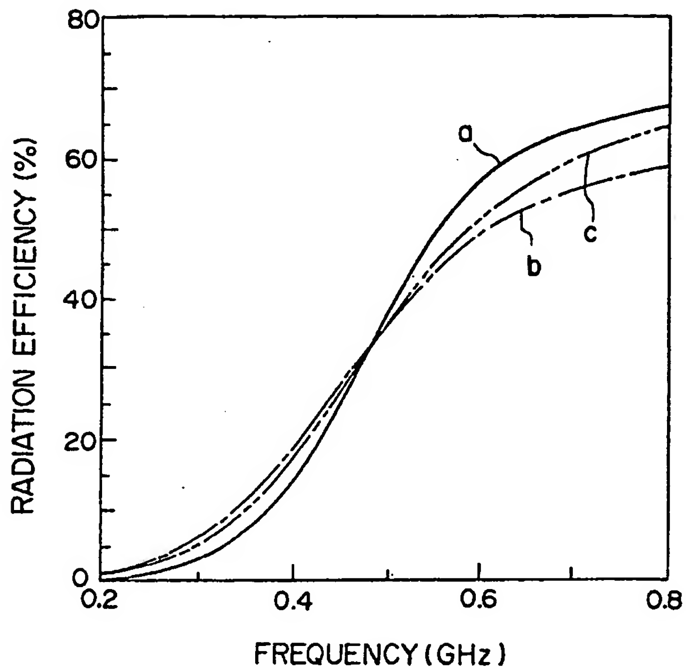


Fig. 4


80
60
40
20
0
0.2
0.4
0.6
0.8
RADIATION EFFICIENCY (%)
FREQUENCY (GHz)
a
b
c

5/5

Fig. 5A

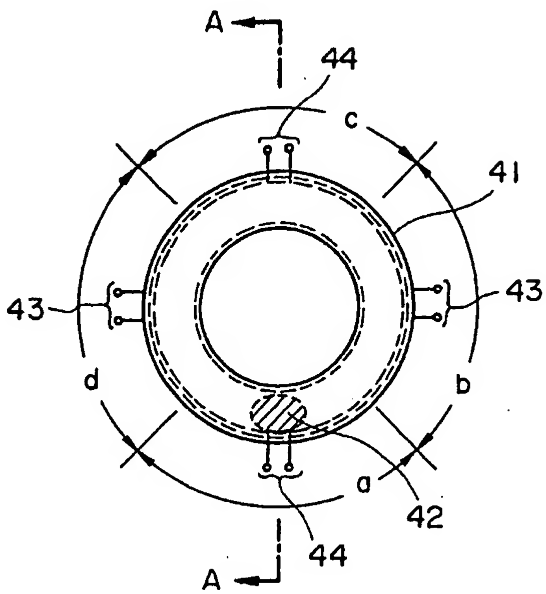
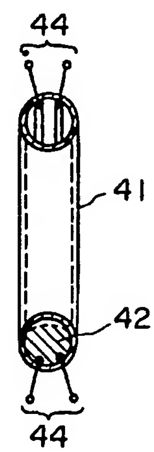


Fig. 5B



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MINIATURE ANTENNA

The present invention relates to a miniature antenna for use with a portable miniature radio transceiver or the like.

Conventionally, loop antennas or monopole antennas are widely employed for portable miniature radio transceivers and they are inevitably adapted for operation primarily in the plane of vertical polarization. Vertically polarized electric waves transmitted from a transmitting station toward a receiver are partly rendered into a horizontally polarized component under the influence of surrounding conditions, and in general, the vertically polarized component is received with an intensity several times higher than the horizontally polarized component. The distance range of communication significantly differs depending on whether the plane of polarization of the receiving antenna is held to be vertical or horizontal with respect to such incoming electric waves. For example, in case of a pager receiver using a loop antenna, its receiving sensitivity markedly differs depending on whether the receiver is placed longitudinally or sideways.

Conventional portable miniature radio transceivers have not taken any counter measures to this disadvantage.

For instance, the prior art pager receiver is equipped with an antenna in such a manner that the receiving sensitivity is maximum when it is carried vertically in a breast pocket of the user's shirt, but in practice, it is often carried in a pocket of a jacket, a bag, a handbag, or the like. In such a case, the pager receiver is usually laid at its side, that is, it is kept

in the direction in which the directivity is the lowest, resulting in the coverage of communication being seriously impaired.

An object of the present invention is to provide a miniature antenna for portable miniature radio transceivers which is designed so that its directional patterns are always optimized through utilization of terrestrial gravitation to keep optimum receiving sensitivity, thereby improving the distance range of communication.

The miniature antenna of the present invention is characterised in that it comprises a pair of parallel-opposed rectangular conductor plates assembled together by an insulating frame interposed and defining therebetween a space sufficiently smaller than the wavelength used; feeding points are each provided at a desired position on one side of each conductor plate, and short-circuit elements, each of which can be short-circuited in high-frequency-wise by a conductor or capacitor, are provided at a plurality of desired positions on other sides of the conductor plates; and one of the short-circuit elements is actuated so that a plane of polarization can always be obtained in a fixed direction with respect to terrestrial gravitation through utilization of gravity, thereby forming a flat plate-shaped loop antenna which is used also as a receiver case. That is to say, a gravity-direction sensor is provided in a portable miniature radio transceiver having such a miniature antenna and the output of the gravity-direction sensor corresponding to the direction in which the radio transceiver is placed is used to short-circuit one of the short-circuit elements so that the plane of polarization of the antenna is aligned with the direction of gravity, i.e. the

plane of vertical polarization of electric waves being transmitted.

With such a structure, the direction of the plane of polarization of the antenna is switched to an optimum direction in accordance with the state of the transceiver being carried so that the coverage of communication can be optimized. In other words, it is possible to overcome a defect of the prior art that the direction of the antenna changes with the state of the transceiver being carried and the receiving sensitivity decreases accordingly, resulting in the deterioration of the communication coverage.

Embodiments of the present invention will now be described, by way of example, in comparison with prior art and with reference to the accompanying drawings, in which:

Figs. 1A, 1B, 1C and 1D are diagrams explanatory of directional patterns of a conventional pager receiver, obtained by measuring its receiving sensitivity when the receiver was turned about the X, Y and Z axes with respect to the direction of arrival of incoming electric waves;

Fig. 2A is a perspective view showing an embodiment of the miniature antenna of the present invention;

Fig. 2B is its system diagrams;

Figs. 3A, 3B and 3C are diagrams of directional patterns of the embodiment of the miniature antenna shown in Figs. 2A and 2B;

Fig. 3D is a diagram explanatory of their angular relationship;

Fig. 4 is a diagram explanatory of variations of the

antenna radiation efficiency in the embodiment; and

Fig. 5 is a diagram illustrating an embodiment of a gravity-direction sensor.

With reference to Figs. 1A, 1B, 1C and 1D, directional patterns of the receiving sensitivity of a card typed pager receiver will first be described. The values indicated were obtained by measuring the receiving sensitivity to vertically polarized electric waves incoming from the Z-axis direction at each 45° rotation angle of the receiver about the Y-axis. In Fig. 1 the receiving sensitivity, indicated in decibels, decreases to inner ones of the concentric circles. The directional patterns in the cases of the pager receiver being placed (1A) vertically (longitudinally), (1B) horizontally, and (1C) sideways are indicated by the solid line, the broken line, and the one-dot chain line respectively. It is evident from Figs. 1A, 1B and 1C that the sensitivity is significantly low when the pager receiver is held sideways as shown in Fig. 1C.

Fig. 2A is a perspective view illustrating the construction of an embodiment of the miniature antenna according to the present invention and Fig. 2B a block diagram showing a gravity-direction sensing short-circuit element control system. In Fig. 2A, reference numerals 1 and 2 indicate a pair of rectangular conductor plates disposed in parallel with a spacing <u>h</u> sufficiently smaller than the wavelength used, and 3 designates an insulating frame interposed between the pair of conductor plates 1 and 2. The conductor plates and the insulating frame constitute a flat loop antenna element and, at the same time, serves as a case for the transceiver. The case is a flat

rectangular parallelepiped (a "card") with a length ℓ of 80 mm, a width W of 50 mm and a height (or thickness) h of 3.6 mm, and the case has incorporated therein functional circuits of the transceiver, together with a gravity-direction sensor 4 and a control circuit 5 shown in the system diagram of Fig. 2B. It will be appreciated that, in relation to, for example, very high frequency radio waves of 300 Mega Hertz having a wavelength of 1 meter, a spacing h of 3.6 mm (which is less than 1/100 the wavelength) is considered to be sufficiently smaller than the wavelength used.

Feeding points are provided at desired positions on one side of the pair of conductor plates 1 and 2, i.e. at a pair of opposed corners D and D' of the plates in this embodiment, and short-circuit elements 6 and 7 are provided at two or more desired opposite positions on the other sides of the plates, i.e. at the other opposite corners A, A', C and C' in this embodiment. Any one of the short-circuit elements 6 and 7 is actuated by the output of the control circuit 5 to short-circuit the conductor plates 1 and 2, causing them to serve as the flat loop antenna.

Figs. 5A and 5B schematically illustrate the construction of an embodiment of the gravity-direction sensor 4, Fig. 5A being its front view and Fig. 5B a sectional view taken on the line A-A in Fig. 5A. In Figs. 5A and 5B, reference numeral 41 indicates a hollow circular ring made of an insulator, and 42 a ball of mercury which is freely movable in the hollow of the ring by gravity. The interior of the circular ring 41 is divided into sections a, b, c and d, in which parallel rail-shaped contacts 43 and 44 are provided extending along the inner wall of the ring.

Even if the direction of the circular ring 41 is changed, the ball of mercury 42 always stays at the lowest position by gravity and short-circuits the contacts in that one of the sections a, b, c and d in which it happens to lie. The output contacts 44 are short-circuited when the receiver, and consequently, the antenna is held almost vertically, that is, when the ball of mercury 42 lies in the section a or c. The output contacts 43 are short-circuited when the receiver or antenna is held sideways, that is, when the ball of mercury 42 is positioned by gravity in the section b or d. In consequence, the gravity-direction sensor 4 produces an output accordingly.

Reference numeral 5 identifies a control circuit, which outputs a control signal for actuating the short-circuit element 6 or 7 by the output signal from the gravity-direction sensor 4.

Figs. 3A, 3B and 3C show gain characteristics of the antenna of this embodiment in the plane of polarization in the Z-axis direction in the cases where feed is effected from the pair of opposed corners D and D' and the corners A and A', B and B' and C and C' are short-circuited, respectively. A notation θ in Fig. 3D indicates the inclination of the plane of polarization from the X axis. That is, polarized waves with $\theta = 0°$ and $\theta = 90°$ are parallel to the X axis and Y axis, respectively. In any case, the direction of polarized waves of high radiation intensity is substantially in agreement with the direction in which the short-circuit point is viewed from the feeding point.

As is evident from Figs. 3A to 3D, the polarized wave directivity characteristic of the receiving field can be changed by shifting the short-circuit points on the pair of parallel-

opposed conductor plates 1 and 2 to desired positions on their marginar edges. This means that the directivity of the antenna can always be held to be optimum with respect to the direction in which electric waves are received or radiated, through automatic control of the short-circuiting positions.

The curves a through c in Fig. 4 show variations of the radiation efficiency relative to frequency when the opposed corners A and A', B and B', C and C' were short-circuited, respectively.

It was ascertained that the resonance frequency would undergo substantially no variation, no matter which pair of opposed points A and A', B and B', C and C' are short-circuited, and that substantially the same radiation efficiency at the resonance point could also be obtained regardless of the short-circuiting point.

While in the above the short-circuit points between the pair of conductor plates 1 and 2 disposed in parallel are described to be automatically switched between the two points A and A', C and C' so as to facilitate a better understanding of the invention, it was confirmed that substantially the same effect as mentioned above could also be produced when the short-circuit elements are provided at desired points such as B, B' in combination with the gravity-direction sensor 4.

Moreover, although in the above the gravity-direction sensor 4 has been described to be the circular ring 41 which employs a metallic ball (the ball of mercury 42), it is also possible, for further miniaturization, to adopt an arrangement in which a floating phenomenon of liquids such as water and oil so

that the short-circuit elements are selectively actuated in response to a change in their capacitance or inductance.

The short-circuit elements 6 and 7 need only to be short-circuited high-frequency-wise and they can be implemented by pin diodes or varicap diodes. It is also possible to form them as a part of the mechanical structure of the gravity-direction sensor so that the capacitances of the short-circuit elements are directly varied.

The above embodiment has been described in connection with the case where the plane of polarization of the receiving antenna of a receiver is adjusted to the plane of vertically polarized waves sent from the transmitting side, but it is a matter of course that the present invention can be applied to a transmitter so that it transmits electric waves in the plane of vertical polarization.

As described above, according to the present invention, the antenna structure can also be used as the transceiver case, and consequently, the radio transceiver can be miniaturized. Further, the directivity of the antenna can always be held optimum with respect to the direction of arrival of incoming electric waves regardless of the direction in which the radio transceiver is placed. Accordingly, the present invention is highly effective for improving the communication coverage as well as for the implementation of miniature, lightweight and thin (card-like) portable radio transceivers.

CLAIMS:

1. A miniature antenna, comprising:

a pair of rectangular conductor plates disposed in parallel with a spacing sufficiently smaller than the wavelength used and fixed with respect to each other by an insulating frame to form an antenna structure which also acts as a case;

feed terminal means provided at a desired position on each of the conductor plates;

short-circuit elements, provided at a plurality of positions on the conductor plates remote from the feed terminal means to provide a short circuit at high frequencies;

a gravity-direction sensor provided in the case to produce an output in accordance with the direction of gravity;

whereby the plurality of short-circuit elements are selectively short-circuited by means of the output of the gravity-direction sensor so that the plane of polarization of the antenna is brought into agreement with the direction of gravity.

2. A miniature antenna according to claim 1, in which the feed terminal means is provided at one pair of opposed corners of the conductor plates, while the short-circuit elements are provided at other pairs of opposed corners of the conductor plates.

3. A miniature antenna according to claim 1 or 2, in which a gravity-direction sensor comprises a hollow circular ring of insulating material, a ball of mercury held in the hollow circular

ring, and four plates of terminals provided on the hollow circular ring so as to divide the hollow circular ring into four arc sections, each pair of terminals to be short-circuited by the ball of mercury.

4. A miniature antenna substantially as herein described with reference to Figs. 2A and 2B, with or without reference to Figs. 5A and 5B of the accompanying drawings.

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